[0077] The bandwidth of the reflective cholesteric liquid crystals is controllable for wide bandwidths by using a pitch gradient tuning. Using this method layers of cholesteric liquid crystals reflecting adjacent colors such as both blue and green and both green and red are used to precisely tune the colors reflected and transmitted by the display. Using the wider bandwidths allows layers with two color reflecting portions per layer to be constructed instead of three color portions per layer as in the prior art.

[0078] When left handed and right handed CLC color filters having the same structure are both used, white incident light of any type polarization on the pixels is converted to red, green, and blue without polarization state distortion. This color filter works for all polarizations from linear, to circular and even to unpolarized light. When linearly polarized light is incident on such color filters which are used in conjunction with conventional twist nematic or super twist nematic in liquid crystal displays the need for a quarter wave plate that converts circularly polarized light to linear light is eliminated. This simplifies the display system, makes fabrication easier, reduces the cost, removes the color chromaticity problem associated with the limited bandwidth of the wave plate and increases the displays contrast ratio by eliminating light losses due to quarter wave plate bandwidth limitations.

[0079] If just left handed or just right handed circularly polarized light is transmitted from the color filters, a quarter wave plate can be used to make the light linearly polarized for use in displays in conjunction with twisted nematic cells to turn the transmitted light on and off from the viewer in conjunction with a linear analyzer.

[0080] A black matrix of one form or another is necessary in all the liquid crystal displays (LCD). The matrix used in the reflective system is formed by using overlapping reflective color filters to reflect all incident light. Therefore no added layers of reflective materials or light absorbing blocking masks are necessary to create the black matrix.

[0081] The portion of the layer having the same reflective color is enlarged by arrangement of the pixels with like color portions adjacent to have larger easier to make color portions on each layer. This reduces the cost of manufacture of the LCD.

[0082] A polarization preserving diffuser is used with a light collimator to increase the viewing angle of the LCD while keeping the color distortion of the color filter at a minimum level.

[0083] These and other objects of the present invention will become apparent hereinafter and in the Claims to Invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0084] Other objects, advantages and novel features of the present invention will become apparent from the following Detailed Description Of The Invention when considered in conjunction with the accompanying Drawings, wherein:

[0085] **FIG. 1A** is a schematic representation of the prior art CLC-based LCD panel assembly disclosed in FIG. 4 of U.S. Pat. No. 5,822,029;

[0086] **FIG. 1B** is a schematic representation of the prior art CLC-based spectral filtering structure shown in FIG. 5 of U.S. Pat. No. 5,822,029, wherein a quarter-wave retardation film is applied to a broad-band reflective polarizing pattern applied to a dual-layer CLC spectral filter structure, in order to reflect and recycle light off the TFT, wiring and other non-aperture surface areas of an LCD panel used in conjunction with the prior art illumination system of **FIG. 1A**;

[0087] **FIG. 1C** is a schematic representation of the intensity distribution of a typical cold-cathode tungsten light source used in the backlighting structures of prior art LCD panels, showing the multiple spectral emission peaks associated with the primary colors blue, green and red;

[0088] **FIG. 1D** is a schematic representation of prior art CLC-based broad band reflective polarizer for use in an LCD panel assembly, as depicted in **FIG. 1A**, to improve light recycling between the backlighting structure and the spectral filtering structure of the LCD panel assembly;

[0089] **FIG. 1E** is the transmittance characteristics for left handed and right handed circularly polarized (LHCP) and (RHCP) light incident upon and transmitted through the CLC-based reflective broadband polarizer employed in the prior art LCD panel assembly of **FIG. 1A**, at an angle of 0 degrees off the normal thereto;

[0090] FIG. IF is the transmittance characteristics for left handed and right handed circularly polarized (LHCP) and (RHCP) light incident upon and transmitted through the CLC-based reflective broadband polarizer employed in the prior art LCD panel assembly of **FIG. 1A**, at an angle of 30 degrees off the normal thereto;

[0091] **FIG. 1G** is the transmittance characteristics for left handed and right handed circularly polarized (LHCP) and (RHCP) light incident upon and transmitted through the CLC-based reflective broadband polarizer employed in the prior art LCD panel assembly of **FIG. 1A**, at an angle of 50 degrees off the normal thereto;

[0092] **FIG. 1H** is the transmittance characteristics for left handed and right handed circularly polarized (LHCP) and (RHCP) light incident upon and transmitted through the CLC-based reflective broadband polarizer employed in the prior art LCD panel assembly of **FIG. 1A**, at an angle of 70 degrees off the normal thereto;

[0093] **FIG. 2** is an exploded schematic diagram of the first generalized LCD panel construction of the present invention comprising (i) its backlighting structure realized by a quasi-specular reflector, a light guiding panel, a pair of edge-illuminating light sources, a light condensing film, and broad-band polarizing reflective panel, (ii) its array of spectral filtering elements realized as an array of pass-band polarizing reflective elements; and (iii) its spatial-intensity modulating array realized as an array of electronically-controlled polarization rotating elements, a broad-band polarizing reflective panel and a polarization-state preserving light diffusive film layer disposed thereon to improve the viewing angle of the system;

[0094] **FIG. 2A** is a perspective, partially broken away view of the LCD panel shown in **FIG. 2**, showing the electronically-controlled polarization rotating elements associated with a pixel structure thereof;

[0095] **FIG. 2B** is a cross-sectional view of a portion of a first illustrative embodiment of the generalized LCD panel assembly shown in **FIG. 2A**, taken along lines 2B-2B therein;